ERPs reveal how semantic and syntactic processing unfolds across parafoveal and foveal vision in sentence comprehension

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Sentence comprehension requires both semantic and syntactic processing, which elicit different patterns of neural activity. Previous ERP studies that investigated sentence comprehension usually adopted the RSVP paradigm that presents one word a time, which showed a N400 for semantic anomaly and a left anterior negativity (LAN) and/or P600 for syntactic anomaly. However, in natural sentence reading upcoming words are available even before they are foveated, and at least semantic information seems to be processed for words in parafovea (i.e., parafoveal N400, which could mitigate the N400 when targets are foveated; Payne et al., 2019). The present study compared how semantic and syntactic processing unfolds across parafoveal and foveal vision in sentence comprehension by examining readers' EEG when unexpected content or function words were presented. Content words (e.g., dog, eat) have rich semantic information, while function words (e.g., in, her) carry less meaning but reveal grammatical relationship between content words. Thus, reading content words may involve more semantic processing while function words may elicit more syntactic processing (e.g., Brown et al., 1999). However, direct comparison between content versus function words generally involve some confounds (e.g., function words are typically shorter and have higher frequency), therefore in the present study critical comparisons were conducted within each class of word (i.e., unexpected vs. control words).

We tested 24 English monolinguals (*M* age=22; range 19-27). The critical stimuli included 120 sentences, each of which had three conditions:1) the control condition with no errors, 2) the semantic violation condition where the critical content word was replaced by an unexpected one, and 3) the syntactic violation condition where the critical function word was replaced by an unexpected one (see Table 1). These sentences were evenly distributed in three lists in a Latin-square design. Thus, each list included 40 sentences in each of the three conditions plus 40 well-formed filler sentences. We adopted a modified visual RSVP flanker paradigm. Each sentence was presented in sequential three-word chunks, with the to-be-fixated word in the center of the display (foveal target), the upcoming next word to the right of fixation (parafoveal target), and the former central word to the left of fixation. At 400 ms intervals the three words were shifted leftward so that the old central word was on the left, the previous parafoveal word was now the central target word and a new word appeared to the right. To facilitate central word fixation, two yellow vertical bars were placed above and below the central word and the central foveal target was displayed in white letters while the two flanking words were displayed in a slightly dimmer grey (see Fig. 1). Horizontal eye-movement was closely monitored and all trials with horizontal eye-movement were removed. Each participant read a list of sentences silently while EEG was being recorded. At the end of each sentence, they judged if the sentence made sense (yes/no button press).

Unexpected content words elicited a right lateralized N400 when displayed in the parafovea, followed by a longer-lasting, widely distributed positivity starting around 300 ms once the target word was foveated (see Fig. 2). Unexpected function words elicited a left lateralized LAN-like component when presented in the parafovea, followed by a left lateralized, posteriorly distributed P600 when that word was presented in the fovea (see Fig. 3). As predicted, in sentence comprehension content versus function words elicit more semantic versus syntactic processing, respectively. Critically, our results suggest that the combination of negativities and positivities seen to critical words in typical word-by-word RSVP paradigms might mask what is actually a sequence of two overlapping stages in which fast, perhaps automatic processes, perform an initial semantic/syntactic assessment of the upcoming word when it is presented in the parafovea and is then followed by a more in depth attentionally mediated assessment once the word has been foveated (e.g., sentence level re-analysis or repairing).

Table 1. Examples of experimental sentences

Control	The old man was asleep in **the** **chair** when I came back.
Semantic Violation	The old man was asleep in the **cherry** when I came back
Syntactic Violation	The old man was asleep in **of** chair when I came back.

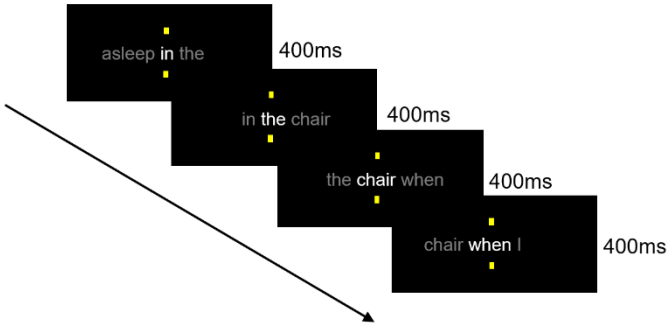

Fig. 1: An illustration of the modified visual RSVP hemi-field flanker paradigm adopted in the present study.

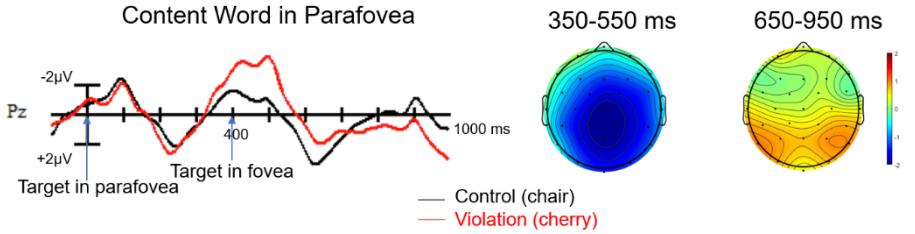

Fig. 2: The ERPs of critical content words and the topographic distribution

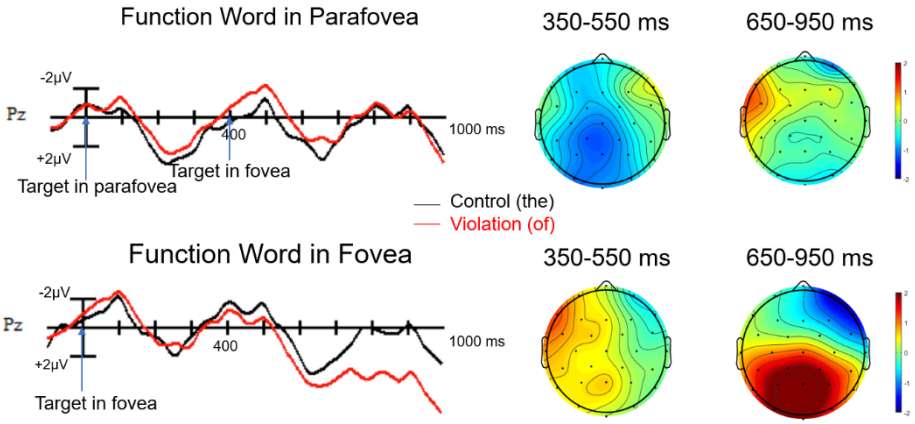

Fig. 3: The ERPs of critical function words and the topographic distribution

Reference

Brown, C. M., Hagoort, P., & Keurs, M. T. (1999). Electrophysiological signatures of visual lexical processing: Open-and closed-class words. *Journal of cognitive neuroscience, 11*(3), 261-281.

Payne, B. R., Stites, M. C., & Federmeier, K. D. (2019). Event-related brain potentials reveal how multiple aspects of semantic processing unfold across parafoveal and foveal vision during sentence reading. *Psychophysiology, 56*(10), e13432.